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(54)【発明の名称】　溶接性に優れたプラスチック成形金型用鋼

(57)【要約】

【目的】溶接性が良好で溶接補修に際して予熱を必要とせず、しかも所要の硬さが得られるとともに原料配合の自由度が高く、経済性に優れたプラスチック成形金型用鋼を提供する。

【構成】プラスチック成形金型用鋼の組成を、重量％でＣ：０．１０～０．２５％，Ｓｉ：０．２５超～０．３５％，Ｍｎ：１．２０～２．２０％，Ｐ：≦０．０２０％，Ｓ：０．０１～０．０５％，Ｃｒ：１．６０～３．００％，Ｍｏ：０．０３～２．００％，Ｖ：０．０１～０．４０％，Ｂ：≦０．００２％，残部実質的にＦｅから成り且つ次式ＢＨ値＝３２６＋８４７．３（Ｃ％）＋１８．３（Ｓｉ％）－８．６（Ｍｎ％）－１２．５（Ｃｒ％）≦４６０を満足する組成とする。

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【特許請求の範囲】
【請求項1】　重量%で
C　：0．10～0．25%
Si：0．25超～0．35%
Mn：1．20～2．20%
P　：≦0．020%
S　：0．01～0．05%
Cr：1．60～3．00%
Mo：0．03～2．00%
V　：0．01～0．40%
B　：≦0．002%
残部実質的にFeから成り且つ下記式
BH値＝326＋847．3（C%）＋18．3（Si%）－8．6（Mn%）－12．5（Cr%）≦460
を満足する組成を有する溶接性に優れたプラスチック成形金型用鋼。
【請求項2】　重量%で
C　：0．10～0．25%
Si：0．25超～0．35%
Mn：1．20～2．20%
P　：≦0．020%
S　：0．01～0．05%
Cr：1．60～3．00%
Mo：0．03～2．00%
V　：0．01～0．40%
B　：≦0．002%
に加えてCu，Niの何れか1種又は2種を
Cu：≦1．0%
Ni：≦2．0%
の範囲で含有し、残部実質的にFeから成り且つ下記式
BH値＝326＋847．3（C%）＋18．3（Si%）－8．6（Mn%）－12．5（Cr%）≦460
を満足する組成を有する溶接性に優れたプラスチック成形金型用鋼。
【請求項3】　重量%で
C　：0．10～0．25%
Si：0．25超～0．35%
Mn：1．20～2．20%
P　：≦0．020%
S　：0．01～0．05%
Cr：1．60～3．00%
Mo：0．03～2．00%
V　：0．01～0．40%
B　：≦0．002%
に加えてZr，Pb，Te，Ca，Biの何れか1種又は2種以上を
Zr：0．003～0．2%
Pb：0．03～0．20%
Te：0．01～0．15%
Ca：0．0005～0．010%

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Bi：0．01～0．20%
の範囲で含有し、残部実質的にFeから成り且つ下記式
BH値＝326＋847．3（C%）＋18．3（Si%）－8．6（Mn%）－12．5（Cr%）≦460
を満足する組成を有する溶接性に優れたプラスチック成形金型用鋼。
【請求項4】　重量%で
C　：0．10～0．25%
Si：0．25超～0．35%
Mn：1．20～2．20%
P　：≦0．020%
S　：0．01～0．05%
Cr：1．60～3．00%
Mo：0．03～2．00%
V　：0．01～0．40%
B　：≦0．002%
に加えてCu，Niの何れか1種又は2種を
Cu：≦1．0%
Ni：≦2．0%
の範囲で含有するとともにZr，Pb，Te，Ca，Biの何れか1種又は2種以上を
Zr：0．003～0．2%
Pb：0．03～0．20%
Te：0．01～0．15%
Ca：0．0005～0．010%
Bi：0．01～0．20%
の範囲で含有し、残部実質的にFeから成り且つ下記式
BH値＝326＋847．3（C%）＋18．3（Si%）－8．6（Mn%）－12．5（Cr%）≦460
を満足する組成を有する溶接性に優れたプラスチック成形金型用鋼。
【発明の詳細な説明】
【0001】
【産業上の利用分野】この発明はプラスチック成形金型用鋼に関し、詳しくは溶接性に優れたプラスチック成形金型用鋼に関する。
【0002】
【従来の技術】プラスチック成形金型においては、金型製作時の加工の誤りや設計変更等に対応するために肉盛溶接による補修を行うことが少なくない。従来、かかるプラスチック成形金型、特に比較的大型のプラスチック成形金型用材料としてはS55C等の一般構造用鋼やSCM445等の中低炭素鋼が用いられていた。
【0003】而してこれら材料から成るプラスチック成形金型の場合、溶接に際して溶接割れ防止のために予熱（250～350℃）を行うことが必要とされ、また場合によって後熱を必要とするものもある。
【0004】しかしながら溶接に際してこのような予熱，後熱を施すとなると専用の加熱炉が必要となったり、加熱に長時間を要したり、予熱後の高温状態の金型

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に対して溶接作業を行うことが必要で作業性が悪い等の問題が生じ、その解決が望まれていた。

【0005】またプラスチック成形金型用鋼としては、焼入性が良好で尚且つ鏡面加工性，シボ加工性に優れ、更に被削性においても優れていることが要求される。

【0006】このようなことから，本発明者等は溶接に際して予熱，後熱を必要としない溶接補修性に優れたプラスチック成形金型用プレハードン鋼を開発し、提案を行っている（特開平3－177536号）。

【0007】

【発明が解決しようとする課題】この特開平3－177536号の発明のプラスチック成形金型用鋼は、Siの含有量を0．25%以下の少ない量に規制すると同時に、不純物としてのP，Bを一定以下に規制し、またSを適量存在させるとともに、溶接時に最大の応力がかかる溶接境界部の母材側の硬さBH値を所定値以下に抑制し、併せて焼入性向上元素の添加量を多くすることによって溶接性の向上，プラスチック成形金型用鋼として必要な硬さと加工性を確保した点を特徴とするものである。

【0008】しかしながらSiは鉄鋼材料では極めて広く使用されている元素であり、その含有量を0．25%以下に規制した場合、鋼の特定の特性が良好となるものの、プラスチック成形金型用鋼の製造に当って原料配合上の制約が大きく、経済性を損なう問題も一方において内包している。

【0009】

【課題を解決するための手段】本願の発明はこのような事情を背景としてなされたものである。而して本願の発明は、プラスチック成形金型用鋼の組成を、重量%でC：0．10～0．25%，Si：0．25超～0．35%，Mn：1．20～2．20%，P：≦0．020%，S：0．01～0．05%，Cr：1．60～3．00%，Mo：0．03～2．00%，V：0．01～0．40%，B：≦0．002%，残部実質的にFeから成り且つ下記式

BH値＝326＋847．3（C%）＋18．3（Si%）－8．6（Mn%）－12．5（Cr%）≦460

を満足する組成となしたことを特徴とする（請求項1）。

【0010】ここで、上記成分に加えて選択元素としてCu，Niの何れか1種又は2種を、Cu：≦1．0%，Ni：≦2．0%の範囲で含有させることができ、更に他の選択元素としてZr，Pb，Te，Ca，Biの何れか1種又は2種以上を、Zr：0．003～0．2%，Pb：0．03～0．20%，Te：0．01～0．15%，Ca：0．0005～0．010%，Bi：0．01～0．20%の範囲で含有させることができる。

【0011】

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【作用】本発明は、添加可能なSiの量を多くすることによって原料配合上の制約を緩和しつつ、尚且つ特開平3－177536号のプラスチック成形金型用鋼と同様、溶接に際して予熱，後熱を必要としない溶接性に優れたプラスチック成形金型用鋼を得るべくなされたもので、Siの含有量の上限を0．35%まで拡大し（下限は0．25%超）、且つこれを許容するための他の合金成分の添加量及び添加量バランスを適正化したことを骨子とする。

【0012】而して本発明によれば、Siを多く含有させることができることからプラスチック成形金型用鋼の製造に当って原料配合の自由度、即ち使用可能な原料の自由度が高まって経済性が高まるとともに、溶接性，焼入性等の特性に優れたプラスチック成形金型用鋼を得ることができる。

【0013】次に上記合金成分の働きと含有量の限定理由を詳述する。

C：0．10～0．25%

Cは組織と硬さを調整するための基本的な添加元素である。Cは熱処理残留応力を除去するための600℃程度の焼戻しにおいて所要の硬さを確保するために（望ましくはHRC25以上、より望ましくは28以上）0．10%以上必要である。一方0．25%を超えて含有させると、下記Siの含有量の下で溶接性の低下を招き、また組織がマルテンサイト組織化して被削性が低下する。従って上限を0．25%とする。

【0014】Si：0．25超～0．35%

Siは脱酸作用，耐酸化性，焼入性，基地硬さを高める点で有効な成分である。但し0．25%以下では原料配合面で経済性が悪いため0．25%を超える量とする。一方0．35%より多くなると靭性，溶接性が低下するため上限を0．35%とする。

【0015】Mn：1．20～2．20%

Mnは脱酸作用のため、またベーナイト組織を得るための焼入性，基地硬さの向上のため、更にSと結合して被削性を付与するための成分として有効な成分である。またMnは一定量以上添加することによって溶接性を高める働きも有する。但しそのためには1．20%以上含有させる必要がある。一方2．20%を超えると溶接性と被削性が低下するため上限を2．20%とする。

【0016】P：≦0．020%

Pは溶接割れ感受性にとって有害であり、その上限を0．020%とする必要がある。

【0017】S：0．01～0．05%

SはMnと結合して被削性を付与し、また溶接割れ防止にも有効である。但し多過ぎると靭性，熱間加工性が低下する。本発明ではSを0．01～0．05%の範囲で含有させることが必要である。

【0018】Cr：1．60～3．00%

Crは耐酸化性，ベーナイト組織を得るための焼入性，

焼戻時の微細炭化物析出による硬さ確保に有効な成分である。またＣｒを１．６０％以上とすることによって良好な溶接性を確保することができる。他方３．００％を超えて多く含有させると組織がマルテンサイト組織化して硬さが過剰となり、被削性が低下する。

【００１９】Ｍｏ：０．０３～２．００％

Ｍｏは焼入性を高めるとともに６００℃以上での焼戻軟化抵抗性を与える。そのための必須添加量として０．０３％以上が必要である。一方２．００％を超えて含有させると被削性が低下するとともにコストアップを招くので上限を２．００％とする。

【００２０】Ｖ：０．０１～０．４０％

Ｖは焼戻時の微細炭化物析出による硬さ確保の上で、また結晶粒を微細化する上で有効な成分であり、本発明では０．０１％以上含有させる。但し０．４０％を超えて含有させると被削性，靭性が低下するとともに溶接性が低下してしまう。

【００２１】Ｂ：≦０．００２％

Ｂは溶接割れ感受性にとって有害であり、０．００２％以下に規制する必要がある。

【００２２】Ｃｕ：≦１．０％

Ｎｉ：≦２．０％

ＣｕおよびＮｉは必要な硬さを得るために加えられる成分で何れも本発明において選択添加元素である。ここでＣｕは５００℃以上での焼戻しにおいて析出硬化により硬さを得るために有効であり、一方多過ぎると熱間加工性を害する。そこで本発明では上限を１．０％とする。Ｎｉは焼入性向上に寄与する元素で２．０％以下の範囲で含有させる。この上限を超えると被削性が悪くなる。

【００２３】Ｚｒ：０．００３～０．２％

Ｐｂ：０．０３～０．２０％

Ｔｅ：０．０１～０．１５％

Ｃａ：０．０００５～０．０１０％

Ｂｉ：０．０１～０．２０％

これらの成分は何れも被削性を高めるために有効な成分である。このうちＺｒは硫化物の展伸を抑えて靭性を向上させる作用もするが、０．２％を超えるとむしろ被削性が低下する。また他の各元素は上記上限値を超えると

地傷やブラックスポットを発生させるため、各上限値以下の範囲で含有させる。

【００２４】ＢＨ値＝３２６＋８４７．３（Ｃ％）＋１８．３（Ｓｉ％）－８．６（Ｍｎ％）－１２．５（Ｃｒ％）≦４６０

ここでＢＨ値は溶接時に最大応力が加わる溶接境界部の母材側の硬さ（Ｈｖ）の値で、それぞれ括弧内の合金成分の関数として表される。

【００２５】本発明者は、溶接境界部の母材側の硬さＢＨ値がＨｖで４６０を境として溶接割れ率が急激に変化し、Ｈｖが４６０を超えると溶接割れ率が急激に高まる事実を確認し、先の特許願（特開平３－１７７５３６号）において開示している。

【００２６】本発明におけるＢＨ値の規定はこれに沿ったものであって、ＢＨ値を４６０以下に抑えることによって溶接割れを抑制でき、予熱，後熱を行わなくてもプラスチック成形金型に対し良好に溶接補修を行うことが可能となる。

【００２７】上記式に現れているようにＢＨ値はＣとＳｉの増大につれて高くなり、また逆にＭｎ，Ｃｒ量の増大に応じて値が低くなる。本発明はＳｉの含有量を上記特開平３－１７７５３６号の鋼種よりも高くしており、その点で溶接性については悪化する傾向となるが、一方でＣの上限値を下げ且つＭｎ及びＣｒの添加量の下限値を高めており、Ｓｉの増量による溶接性への悪影響をそれらによって解消している点に特徴がある。

【００２８】

【実施例】次に本発明の実施例を以下に詳述する。表１に示す組成の鋼を溶製及び鍛造した後、以下の条件で熱処理を施し、試験片を作製してＪＩＳ－Ｚ３１５８に規定する斜めＹ型溶接割れ試験を実施した。その結果が硬さとともに表２に示してある。

【００２９】〈熱処理条件〉

焼入れ　８７０～９５０℃

焼戻し　６２０℃

【００３０】

【表１】

表 1

	実施例1	実施例2	実施例3	実施例4	実施例5	実施例6	実施例7	比較例1	比較例2	比較例3	比較例4
C	0.11	0.15	0.19	0.17	0.21	0.18	0.14	0.27	0.18	0.21	0.19
Si	0.27	0.26	0.28	0.26	0.26	0.31	0.29	0.27	0.37	0.31	0.30
Mn	1.29	1.53	1.49	1.52	2.14	2.01	1.63	2.32	1.60	1.08	1.64
P	0.016	0.006	0.015	0.018	0.014	0.018	0.011	0.016	0.012	0.015	0.019
S	0.042	0.030	0.011	0.027	0.038	0.014	0.021	0.022	0.015	0.061	0.032
Cu	－	－	－	－	0.80	－	－	－	－	－	－
Ni	－	－	－	－	－	1.20	0.36	－	－	－	－
Cr	1.74	2.31	1.86	2.25	2.84	2.74	2.83	1.88	1.74	1.92	1.52
Mo	0.98	1.15	0.36	0.45	0.49	1.39	0.53	0.59	1.21	0.92	0.35
V	－	0.24	0.10	0.10	－	0.29	0.04	0.17	0.09	0.33	0.57
B	0.0012	0.0009	0.0010	0.0007	0.0014	0.0017	0.0013	0.0009	0.0016	0.0004	0.0011
Zr	－	－	－	－	0.007	－	0.05	－	－	－	－
Pb	－	－	－	－	－	0.11	－	－	－	－	－
Te	－	－	－	－	－	－	0.07	－	－	－	－
Ca	－	－	－	－	－	0.0022	－	－	－	－	－
Bi	－	－	－	－	－	－	0.08	－	－	－	－
BH値	391	415	455	433	455	433	401	516	450	476	459

【００３１】
【表２】
表 2

	硬さ(HRC)	溶接割れ率(%)
実施例1	25.4	0
実施例2	30.9	0
実施例3	30.7	0
実施例4	32.6	0
実施例5	37.6	0
実施例6	36.9	0
実施例7	33.5	0
比較例1	39.2	70
比較例2	37.8	30
比較例3	30.1	40
比較例4	33.4	20

＊【００３２】表に示す結果から、本発明例の鋼種の場合溶接性が良好で、しかも高い硬度が得られることが分かる。尚、以上はあくまで本発明の具体例であって、本発明は他の態様で実施することも可能である。

【００３３】

【発明の効果】本発明によれば、プラスチック成形金型用鋼を製造するに当って、合金成分としてのＳｉを多く含有させることが可能となり、金型用鋼の製造に当って原料配合の自由度が高まって経済性が良好となるとともに、溶接性，焼入性等の特性に優れたプラスチック成形金型用鋼を得ることができる。

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PATENT ABSTRACTS OF JAPAN

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(54) STEEL FOR METAL MOLD FOR PLASTIC MOLDING, EXCELLENT IN WELDABILITY

(57)Abstract:

PURPOSE: To produce a steel for a metal mold for plastic molding, excellent in weldability and hardenability, by specifying the chemical composition in a steel and controlling BH value to the prescribed value or below.

CONSTITUTION: This steel has a composition which consists of, by weight, 0.10-0.25% C, >0.25-0.35% Si, 1.20-2.20% Mn, ≤0.020% P, 0.01-0.05% S, 1.60-3.00% Cr, 0.03-2.00% Mo, 0.01-0.40% V, ≤0.002% B, and the balance essentially Fe and in which BH value satisfies the condition represented by the inequality. Further, if necessary, ≤1.0% Cu and ≤2.0% Ni are incorporated into this composition, and further, one or ≥2 kinds among 0.003-0.2% Zr, 0.03-0.20% Pb, 0.01-0.15% Te, 0.0005-0.010% Ca, and 0.01-0.20% Bi are incorporated. By this method, the steel for a metal mold for plastic

blending are relieved by increasing the amount of Si capable of being added and also neither preheating nor postheating is required at the time of welding, can be obtained.

$$BH値 = 326 + 47.3(C\%) + 15.3(Si\%) - 5.6(Mn\%) - 12.5(Cr\%) \leqq 160$$

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TECHNICAL FIELD

[Industrial Application] This invention relates to the steel for plastic-molding metal mold excellent in weldability in detail about the steel for plastic-molding metal mold.

PRIOR ART

[Description of the Prior Art] In plastic-molding metal mold, since it corresponds to an error, a design change, etc. of processing at the time of a metal mold fabrication, it is not rare to perform remedy by build-up welding. Conventionally, as this plastic-molding metal mold and a comparatively large-sized especially charge of plastic-molding metal mold lumber, steel for general structure, such as S55C, and the inside low-carbon steel of SCM445 grade were used.

[0003] In the case of the plastic-molding metal mold which ** and consists of these ingredients, there are some which to preheat on the occasion of welding for weld-cracking prevention (250-350 degrees C) is needed, and need post heating by the case.

[0004] However, when performing such preheating and post heating on the occasion of welding, the heating furnace of dedication was needed, or heating took long duration, or problems, like it is required to perform welding operation to the metal mold of the elevated-temperature condition after preheating, and workability is bad arose, and the solution was desired.

[0005] moreover -- as the steel for plastic-molding metal mold -- hardenability -- good -- in addition -- and to excel in mirror plane workability and crimp workability, and to excel also in machinability further is demanded.

[0006] Since it is such, this invention person etc. is proposing by developing the preharden steel for plastic-molding metal mold excellent in the welding remedy nature which does not need preheating and post heating on the occasion of welding (JP,3-177536,A).

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] The steel for plastic-molding metal mold of invention of this JP,3-177536,A While regulating P as an impurity, and B to below fixed and recognizing optimum dose existence of the S at the same time it regulates the content of Si in 0.25% or less of small amount It is characterized by the point of having secured hardness and workability required as improvement in weldability, and steel for plastic-molding metal mold, by controlling and combining below with a predetermined value the hardness BH value by the side of the base material of the weld junction section which requires the maximum stress at the time of welding, and making [many] the addition of the improvement element in hardenability.

[0008] However, in the ferrous material, Si is an element currently used very widely, and although the specific property of steel becomes good when the content is regulated to 0.25% or less, in manufacture of the steel for plastic-molding metal mold, its constraint on raw material combination is large, and it has also connoted the problem which spoils profitability in one side.

MEANS

[Means for Solving the Problem] This invention is made against the background of such a situation. It **. This invention the presentation of the steel for plastic-molding metal

mold By weight %, C: 0.10 - 0.25%, Si: 0.25 ** -0.35%, Mn: It changes from Fe to a remainder real target 1.20 - 2.20%, P:<=0.020%, S:0.01 - 0.05%, Cr:1.60-3.00%, Mo:0.03-2.00%, V:0.01 - 0.40%, and B:<=0.002%. And following type BH value =326+847.3 It is characterized by making with the presentation with which it is satisfied of +18.3 (Si%)-8.6 (Mn%)-12.5 (Cr%)<=460 (C%) (claim 1).
[0010] It adds to the above-mentioned component here. As a selection element any one sort of Cu and nickel, or two sorts It can be made to contain in Cu:<=1.0% and nickel:<=2.0%. As other selection elements, furthermore, any one sort of Zr, Pb, Te, calcium, and the Bi, or two sorts or more Zr: It can be made to contain in 0.003-0.2%, Pb:0.03-0.20%, Te:0.01-0.15%, calcium:0.0005-0.010%, and Bi:0.01-0.20%.
[0011]

EFFECT OF THE INVENTION

[Effect of the Invention] While according to this invention in manufacturing the steel for plastic-molding metal mold it becomes possible to make many Si as an alloy content contain, the degree of freedom of raw material combination increases in manufacture of the steel for metal mold and profitability becomes good, the steel for plastic-molding metal mold excellent in properties, such as weldability and hardenability, can be obtained.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the steel for plastic-molding metal mold excellent in weldability in detail about the steel for plastic-molding metal mold.
[0002]
[Description of the Prior Art] In plastic-molding metal mold, since it corresponds to an error, a design change, etc. of processing at the time of a metal mold fabrication, it is not rare to perform remedy by build-up welding. Conventionally, as this plastic-molding metal mold and a comparatively large-sized especially charge of plastic-molding metal mold lumber, steel for general structure, such as S55C, and the inside low-carbon steel of SCM445 grade were used.
[0003] In the case of the plastic-molding metal mold which ** and consists of these ingredients, there are some which to preheat on the occasion of welding for weld-cracking prevention (250-350 degrees C) is needed, and need post heating by the case.
[0004] However, when performing such preheating and post heating on the occasion of welding, the heating furnace of dedication was needed, or heating took long duration, or problems, like it is required to perform welding operation to the metal mold of the elevated-temperature condition after preheating, and workability is bad arose, and the solution was desired.
[0005] moreover -- as the steel for plastic-molding metal mold -- hardenability -- good -- in addition -- and to excel in mirror plane workability and crimp workability, and to excel also in machinability further is demanded.
[0006] Since it is such, this invention person etc. is proposing by developing the

preharden steel for plastic-molding metal mold excellent in the welding remedy nature which does not need preheating and post heating on the occasion of welding (JP,3-177536,A).
[0007]
[Problem(s) to be Solved by the Invention] The steel for plastic-molding metal mold of invention of this JP,3-177536,A While regulating P as an impurity, and B to below fixed and recognizing optimum dose existence of the S at the same time it regulates the content of Si in 0.25% or less of small amount It is characterized by the point of having secured hardness and workability required as improvement in weldability, and steel for plastic-molding metal mold, by controlling and combining below with a predetermined value the hardness BH value by the side of the base material of the weld junction section which requires the maximum stress at the time of welding, and making [many] the addition of the improvement element in hardenability.
[0008] However, in the ferrous material, Si is an element currently used very widely, and although the specific property of steel becomes good when the content is regulated to 0.25% or less, in manufacture of the steel for plastic-molding metal mold, its constraint on raw material combination is large, and it has also connoted the problem which spoils profitability in one side.
[0009]
[Means for Solving the Problem] This invention is made against the background of such a situation. It **. This invention the presentation of the steel for plastic-molding metal mold By weight %, C: 0.10 - 0.25%, Si: 0.25 ** -0.35%, Mn: It changes from Fe to a remainder real target 1.20 - 2.20%, P:<=0.020%, S:0.01 - 0.05%, Cr:1.60-3.00%, Mo:0.03-2.00%, V:0.01 - 0.40%, and B:<=0.002%. And following type BH value =326+847.3 It is characterized by making with the presentation with which it is satisfied of +18.3 (Si%)-8.6 (Mn%)-12.5 (Cr%)<=460 (C%) (claim 1).
[0010] It adds to the above-mentioned component here. As a selection element any one sort of Cu and nickel, or two sorts It can be made to contain in Cu:<=1.0% and nickel:<=2.0%. As other selection elements, furthermore, any one sort of Zr, Pb, Te, calcium, and the Bi, or two sorts or more Zr: It can be made to contain in 0.003-0.2%, Pb:0.03-0.20%, Te:0.01-0.15%, calcium:0.0005-0.010%, and Bi:0.01-0.20%.
[0011]
[Function] This invention easing the constraint on raw material combination by making [many] the amount of Si which can be added And it is what was made in order to obtain the steel for plastic-molding metal mold of JP,3-177536,A, and the steel for plastic-molding metal mold which was excellent in the weldability which does not need preheating and post heating on the occasion of welding similarly. in addition -- It makes to have rationalized other additions and addition balance of an alloy content for expanding the upper limit of the content of Si to 0.35% (a minimum being 0.25% **), and permitting this into a main point.
[0012] Since it **, and many Si can be made to contain according to this invention, while the degree of freedom of raw material combination, i.e., the degree of freedom of an usable raw material, increases in manufacture of the steel for plastic-molding metal mold and profitability increases, the steel for plastic-molding metal mold excellent in properties, such as weldability and hardenability, can be obtained.
[0013] Next, work of the above-mentioned alloy content and the reason for definition of a

content are explained in full detail.
C:0.10 - 0.25%C is a fundamental alloying element for adjusting an organization and hardness. C is required 0.10 (28 or more [Desirably 25 or more HRC(s), more desirably])% or more, in order to secure necessary hardness in annealing of about 600 degrees C for removing heat treatment residual stress. On the other hand, if it is made to contain exceeding 0.25%, lowering of weldability will be caused under the content of Following Si, and an organization will do martensite systematization, and machinability will fall. Therefore, an upper limit is made into 0.25%.
[0014] Si: 0.25 ** - 0.35%Si is an effective component at the point which raises deacidification, oxidation resistance, hardenability, and base hardness. However, at 0.25% or less, in respect of raw material combination, since profitability is bad, it considers as the amount exceeding 0.25%. Since toughness and weldability will fall on the other hand if it increases more than 0.35%, an upper limit is made into 0.35%.
[0015] Mn: 1.20 - 2.20%Mn is an effective component as a component for combining with S further and giving machinability for improvement in the hardenability for [for deacidification] obtaining a bainite organization, and base hardness. Moreover, Mn also has the work which raises weldability by adding more than a constant rate. However, it is necessary to make it contain 1.20% or more for that purpose. Since weldability and machinability will fall on the other hand if it exceeds 2.20%, an upper limit is made into 2.20%.
[0016] P: For weld-cracking susceptibility, <=0.020%P is harmful and needs to make the upper limit 0.020%.
[0017] S:0.01 - 0.05%S combines with Mn, and gives machinability, and is effective also in weld-cracking prevention. However, if many [too], toughness and hot-working nature will fall. It is required of this invention to make S contain in 0.01 - 0.05% of range.
[0018] Cr: 1.60-3.00%Cr is a component effective in the hardness reservation by the hardenability for obtaining oxidation resistance and a bainite organization, and the detailed carbide deposit at the time of temper. Moreover, good weldability is securable by making Cr into 1.60% or more. If it is made to contain mostly across 3.00% of another side, an organization will do martensite systematization, and will become superfluous [hardness], and machinability will fall.
[0019] Mo: 0.03 - 2.00%Mo gives temper softening resistance 600 degrees C or more while raising hardenability. 0.03% or more is required as an indispensable addition for that. Since a cost rise will be caused on the other hand while machinability falls if it is made to contain exceeding 2.00%, an upper limit is made into 2.00%.
[0020] V:0.01 - 0.40%V is after the hardness reservation by the detailed carbide deposit at the time of temper, and is a component effective when making crystal grain detailed, and is made to contain 0.01% or more in this invention. However, if it is made to contain exceeding 0.40%, while machinability and toughness will fall, weldability will fall.
[0021] B: <=0.002%B is harmful and it is necessary to regulate it to 0.002% or less for weld-cracking susceptibility.
[0022] Cu:<=1.0%nickel:<= -- Cu and nickel are all selection alloying elements in this invention of the component added in order to obtain required hardness 2.0%. Cu is effective in order to obtain hardness by precipitation hardening in annealing at 500 degrees C or more, and on the other hand, if many [too], hot-working nature will be injured here. So, an upper limit is made into 1.0% in this invention. nickel is made to

contain in 2.0% or less of range by the element contributed to the improvement in hardenability. If this upper limit is exceeded, machinability will worsen.
[0023] Zr:0.003-0.2%Pb:0.03-0.20%Te:0.01-0.15%calcium:0.0005 - 0.010%Bi: -- 0.01 to 0.20%, each of these components is effective components, in order to raise machinability. Among these, although the operation which Zr suppresses the expansion of a sulfide and raises toughness is also carried out, if it exceeds 0.2%, machinability will fall rather. Moreover, if the above-mentioned upper limit is exceeded, in order that each of other element may generate a sand mark and a black spot, it is made to contain in the range below each upper limit.
[0024] BH value = -- 326+847.3 (C %)+18.3 (Si%)-8.6 (Mn%)-12.5 (Cr%)<=460 -- at the time of welding, BH value is a value of the hardness by the side of the base material of the weld junction section which maximum stress joins (Hv), and is expressed as a function of the alloy content in a parenthesis here, respectively.
[0025] The rate of weld cracking changes [the hardness BH value by the side of the base material of the weld junction section] rapidly bordering on 460 by Hv, this invention person will check the data that the rate of weld cracking increases rapidly, if Hv exceeds 460, and he is indicating in a previous patent application (JP,3-177536,A).
[0026] Along with this, even if a convention of BH value in this invention can control weld cracking and does not perform preheating and post heating by holding down BH value or less to 460, it becomes possible [performing welding remedy good to plastic-molding metal mold].
[0027] As it has appeared in the above-mentioned formula, BH value becomes high along with buildup of C and Si, and a value becomes low at reverse according to buildup of Mn and the amount of Cr(s). Although this invention makes the content of Si higher than the steel type of above-mentioned JP,3-177536,A and serves as an inclination which gets worse about weldability at the point, the lower limit of the addition of lowering, and Mn and Cr is raised for the upper limit of C by one side, and the description is that it has canceled the adverse effect to the weldability by loading of Si by them.
[0028]
[Example] Next, the example of this invention is explained in full detail below. After ingoting and forging the steel of the presentation shown in a table 1, it heat-treated on condition that the following, and the slanting Y mold weld cracking test which produces a test piece and is specified to JIS-Z3158 was carried out. The result is shown in a table 2 with hardness.
[0029] <Heat treatment conditions> Hardening 870-950-degree-C annealing 620 degrees C [0030]
[A table 1]

表 1

	実施例1	実施例2	実施例3	実施例4	実施例5	実施例6	実施例7	比較例1	比較例2	比較例3	比較例4
C	0.11	0.15	0.19	0.17	0.21	0.18	0.14	0.27	0.18	0.21	0.19
Si	0.27	0.26	0.28	0.26	0.26	0.31	0.29	0.27	0.37	0.31	0.30
Mn	1.29	1.53	1.49	1.52	2.14	2.01	1.63	2.32	1.60	1.08	1.64
P	0.016	0.006	0.015	0.018	0.014	0.018	0.011	0.016	0.012	0.015	0.019
S	0.042	0.030	0.011	0.027	0.038	0.014	0.021	0.022	0.015	0.061	0.032
Cu	—	—	—	—	0.80	—	—	—	—	—	—
Ni	—	—	—	—	—	1.20	0.36	—	—	—	—
Cr	1.74	2.31	1.86	2.25	2.84	2.74	2.83	1.88	1.74	1.92	1.52
Mo	0.98	1.15	0.36	0.45	0.49	1.39	0.53	0.59	1.21	0.92	0.35
V	—	0.24	0.10	0.10	—	0.29	0.04	0.17	0.09	0.33	0.57
B	0.0012	0.0009	0.0010	0.0007	0.0014	0.0017	0.0013	0.0009	0.0016	0.0004	0.0011
Zr	—	—	—	—	0.007	—	0.05	—	—	—	—
Pb	—	—	—	—	—	0.11	—	—	—	—	—
Te	—	—	—	—	—	—	0.07	—	—	—	—
Ca	—	—	—	—	—	0.0022	—	—	—	—	—
Bi	—	—	—	—	—	—	0.08	—	—	—	—
BH値	391	415	455	433	455	433	401	516	450	476	459

[0031]
[A table 2]
表 2

	硬さ(HRC)	溶接割れ率(%)
実施例1	25.4	0
実施例2	30.9	0
実施例3	30.7	0
実施例4	32.6	0
実施例5	37.6	0
実施例6	36.9	0
実施例7	33.5	0
比較例1	39.2	70
比較例2	37.8	30
比較例3	30.1	40
比較例4	33.4	20

[0032] In the case of the steel type of the example of this invention, weldability is good, and the result shown in a table shows that a high degree of hardness is moreover obtained. In addition, the above is the example of this invention to the last, and this invention can also be carried out in other modes.
[0033]

[Effect of the Invention] While according to this invention in manufacturing the steel for plastic-molding metal mold it becomes possible to make many Si as an alloy content contain, the degree of freedom of raw material combination increases in manufacture of the steel for metal mold and profitability becomes good, the steel for plastic-molding metal mold excellent in properties, such as weldability and hardenability, can be obtained.